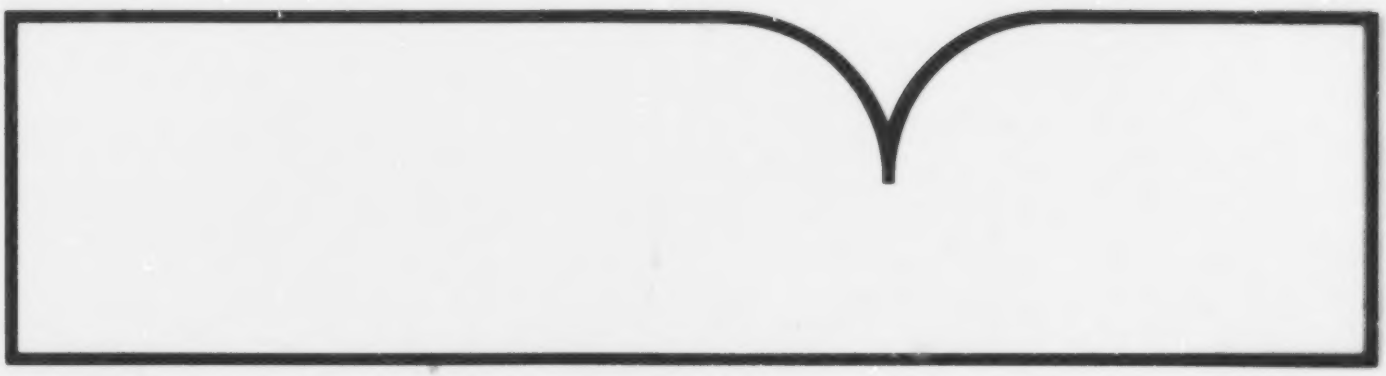
PB85-152486

Application of a Hazard Assessment Research Strategy to the Ocean Disposal of a Dredged Material: Monitoring Component

(U.S.) Environmental Research Lab.
Narragansett, RI

Dec 84



U.S. Department of Commerce
National Technical Information Service
NTIS

PB85-152486

EPA-600/D-84-287
December 1984

THE APPLICATION OF A HAZARD ASSESSMENT RESEARCH STRATEGY TO THE OCEAN DISPOSAL OF A DREDGED MATERIAL: Monitoring Component

by

Donald K. Phelps, K. John Scott, Bruce H. Reynolds,
Jeffrey S. Rosen, and James L. Lake

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
NARRAGANSETT, RI 02882

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/D-84-287		

4. TITLE AND SUBTITLE	5. REPORT DATE
THE APPLICATION OF A HAZARD ASSESSMENT RESEARCH STRATEGY TO THE OCEAN DISPOSAL OF A DREDGED MATERIAL: Monitoring Component	December 1984
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) D. K. Phelps, B. H. Reynolds, J. S. Lake, K. J. Scott, and J. S. Rosen	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS same as block 12	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Research Laboratory--ERL-Narr Office of Research and Development U.S. Environmental Protection Agency Narragansett, RI 02882	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA/600/05

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The monitoring component of the Field Verification Program (FVP) ultimately provides a "real world" test for assessing the rest of the project. It is a research effort, as are the other components of this program. The objective is to evaluate the hazard assessment strategy and to recommend the application of monitoring tools in several other specific areas: (1) linkage of measurements and responses between laboratory and field; (2) permit applications; (3) compliance monitoring. To reach these objectives, traditional tools, such as benthic community analysis, are being compared to more recently developed approaches, such as the REMOTS interface camera.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	56
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

THE APPLICATION OF A HAZARD ASSESSMENT RESEARCH STRATEGY TO THE OCEAN DISPOSAL OF A DREDGED MATERIAL: MONITORING COMPONENT

Donald K. Phelps, K. John Scott, Bruce H. Reynolds,
Jeffrey S. Rosen, James L. Lake,

U. S. Environmental Protection Agency
Environmental Research Laboratory
Narragansett, Rhode Island 02882
U. S. A.

ABSTRACT v

1. INTRODUCTION 1

2. EXPERIMENTAL DESIGN 3

2.1. Site Selection 3

2.2. Station Selection 4

2.3. Species Selection 6

2.4. Data Management System 7

3. RESULTS & DISCUSSION 9

3.1. Disposal Mound Morphology 9

3.2. Biochemical Response — AEC 11

3.3. Cellular Response — SCE 12

3.4. Tissue Response — Histopathology 15

3.5. Whole Organism Responses 16

3.5a. Scope For Growth 16

3.5b. Bioenergetics 17

3.6. Bioaccumulation 17

3.6a. Organic 17

3.6b. Inorganic 19

3.7. Population Response -- Demographics ... 20

3.8. Community Response 21

3.9. REMOTS Interface Camera 26

4. CONCLUSIONS 29

ACKNOWLEDGMENTS 32

REFERENCES 33

ABSTRACT

The monitoring component of the Field Verification Program (FVP) ultimately provides a "real world" test for assessing the rest of the project. It is a research effort, as are the other components of this program. The objective is to evaluate the hazard assessment strategy and to recommend the application of monitoring tools in several other specific areas: 1) linkage of measurements and responses between laboratory and field, 2) permit applications, 3) compliance monitoring. To reach these objectives, traditional tools, such as benthic community analysis, are being compared to more recently developed approaches, such as the REMOTS interface camera.

Station locations were selected to simulate a dose response. The experimental design includes both pre- and post-disposal sampling of a variety of physical, chemical, and biological parameters. Biological responses are being measured in both indigenous and introduced species; and the tiered testing approach, used in the laboratory, is also being applied in the field. The biological responses are being measured at the molecular, cellular, tissue, and whole animal levels, as well as at the population and community levels.

1. INTRODUCTION

The Field Verification Program (FVP), is a multidisciplinary study of a single but complex source of pollution studied under both laboratory and field conditions using a hazard assessment strategy as the conceptual framework. A basic premise of the hazard assessment strategy is that a tiered testing approach can be used to make predictions of environmental hazards with successively greater predictability as one moves from lower to higher testing tiers. The monitoring program in the FVP provides the "real world" data that will be used to verify whether the predictions generated from the tiered approach are correct. In addition, the monitoring program provides the necessary data to evaluate whether laboratory effects are similarly manifested in the field. This program provides a unique opportunity to assess the potential of a variety of monitoring tools. The five components of the hazard assessment strategy include site and waste characterization, effects assessment, exposure assessment and monitoring. This paper discusses the monitoring component of the FVP.

The primary objective is to evaluate potential monitoring tools using field validation of predictions within the hazard assessment strategy as criteria. Other agency monitoring needs that may be served include the

following: 1) permit applications for ocean disposal activities; 2) compliance monitoring; and 3) determination of baseline conditions.

The monitoring component of the FVP is treated in this paper as a research effort. It is not to be confused with the term "monitoring" as used to describe an application of standardized techniques to achieve specific goals in support of legally mandated monitoring requirements. The monitoring research component is expected to yield a suite of techniques that may be applied, in the future, to support traditional monitoring objectives.

In support of these goals and objectives, the techniques being evaluated as potential monitoring tools include a combination of traditional as well as innovative approaches. Traditional qualitative and quantitative analyses of benthic communities are compared to more recently developed use of the REMOTS interface camera. Caged transplants are used in conjunction with indigenous fauna for purposes of biomonitoring. A variety of organisms representing different taxonomic groups and feeding types are studied from collections taken at the same time and the same place. Animal tissue chemical residues are determined as well as biological effects. Different levels of organization within and between animals are being monitored, ranging in complexity from biochemical

systems within the individual, through integrative measures of whole animal well-being, to population and community considerations.

The purpose of the study, therefore, is not to search for a single endpoint that will provide a universal solution to biological monitoring needs. Rather, as is indicated above, a multidisciplinary approach is emphasized. Achievement of the objectives and goals of this study should allow the selection of an optimum suite of monitoring tools, minimized on the basis of resource requirements, to adequately address monitoring needs on a case by case basis.

2. EXPERIMENTAL DESIGN

2.1 Site Selection

The Field Verification Program (FVP) is being conducted in the Central Long Island Sound Disposal Site (CLIS) which is located south of New Haven, CT. The site for the disposal of Black Rock Harbor (BRH) material was designated in the northeast corner of the CLIS rectangle (Fig. 1). This area of the disposal site was chosen based on site designation surveys carried out by the New England Division of the Army Corps of Engineers in spring and summer of 1982 (Morton, 1982) and in the spring of 1983 (Scott et al., 1984 (in prep)). The criteria for this site designation were: the minimal potential for environment

impact; the reduction of interference from other ongoing disposal operations in Central Long Island Sound; and the homogeneous nature of the site in terms of bottom topography, sediment chemistry, grain size and the benthic community. The physical characteristics of the site before, during, and after the disposal of BRH material were evaluated using precision bathymetry, side scan sonar, suspended solids and current measurements, REMOTS interface camera image analyses, sediment chemistry and grain size analyses.

2.2 Station Selection

In order to determine the number of stations necessary to achieve the FVP monitoring goals, an initial 42 station survey (Fig. 2a) was conducted to measure the large scale variability in the benthic community. In a second survey, 6 stations were sampled intensively to estimate the small scale variability, i.e., within-station variance, and to determine benthic sample sizes and numbers of replications necessary to distinguish future alterations in the community structure. Results of the surveys indicated that the study area was relative uniform, i.e., a low degree of large scale variability, and that 5 replicate .1 m2 grab samples would be adequate for describing the benthic community.

In addition to the traditional measures of benthic

community structure, the REMOTS (TM) (Marine Surveys, Inc., New Haven, CT) sediment-profile camera was used to survey the disposal site during August, 1982. Fifty-one stations were located on an orthogonal grid, plus the two control stations. The purpose of the REMOTS survey was: first, to define the benthic habitat through measurements of redox depth, boundary roughness, estimated major sediment mode, and spatial distribution of infaunal successional stages, and secondly to provide a ground truth sampling program for pre- and post-disposal monitoring of benthic conditions.

The selection of stations for the field component of the FVP was based on the idea that the field measurements should reflect a gradient of exposure to BRH sediments. As such, the highest exposure would be expected at the center of the disposal site and the lowest or zero exposure at a control station with no BRH sediments present. A transect of intermediate stations, along the axis of tidal currents was established. These sample locations could then be used for later simulation in the laboratory as a dose series analogous to that used for dose-response experiments.

On this basis, five major stations were selected for biological sampling (Fig. 2b): Center, 200E, 400E, 1000E, and South Reference. The Center, located at the center of the disposal pile, represents the highest level of exposure to BRH material. The South Reference station, located 3 km

to the south-southwest, was chosen because there was little likelihood of contaminated BRH sediment reaching that site, and there exists historical information from that site due to its previous use as a DAMOS control site (Morton, 1982). Stations 200E (200 meters east) and 400E were chosen to bracket the edge of the pile, the location of which was predicted from previous dumping experience. Post-disposal observations verified this assumption. The 1000E station was selected as an additional control station, located closer to the experimental site and at the same depth.

Baseline samples for benthic community measures were taken quarterly for one year prior to disposal. Pre-disposal conditions were established for all of the other biological endpoints as well. Sampling was conducted immediately following disposal and at 2, 8, 12, and 16 weeks after disposal and is continuing on a quarterly basis. Thereafter sampling was conducted quarterly. It was desirable to have as much commonality of sampling as possible. Therefore, where multiple measures were to be made on the same species, for example Nephtys incisa or Mytilus edulis, the organisms for these measures were collected at the same time and supplied to the various researchers involved.

2.3 Species Selection

The species selected for intense study under the field

component of the FVP were chosen for several reasons. A major consideration was to use animals that could be collected and analyzed directly from the field, as well as be tested under laboratory conditions. Therefore, criteria presented by Johns et al., Chapter OO, apply to the choice of field animals as well as to those selected for use in the biological effects studies.

Because Nephtys incisa is a dominant species in ubiquitously distributed soft bottom benthic communities, it was selected particularly for these field monitoring studies. Moreover, it has adequate biomass for tissue chemical analytical needs, and its numbers are reasonably stable, assuring adequate supply for experimental use without jeopardizing existing populations. N. incisa lives in close association with and feeds upon the sediments. Mytilus edulis, introduced as a caged transplant, was chosen because it has been demonstrated to be amenable to caging. This species feeds on particles suspended in the water column, therefore it does not require a sediment substrate. The choice of these species provides representatives of different taxonomic and feeding types and is therefore compatible with the objectives of the FVP field component.

2.4 Data Management System

The degree of success of the Field Verification

Program depends not only on the experimental design and the quality of the collected data, but also on the ability to bring together data generated within the five components of the hazard assessment approach for statistical analysis. Without this capability the synthesis of the varied types of data would be difficult. The data include both field monitoring and laboratory experiments. Further, they are biological, chemical, geological or physical in nature. The system which has been developed is capable of storing, manipulating and summarizing these raw data, which are then made available to all.

System requirements have been met using DATMAN, a relational database system developed at the Environmental Research Laboratory, Narragansett (Bass, 1982). A hierarchical system has been imposed on the relational database system allowing the subsetting of raw observations using summary information stored in separate data files. The general structure of the system is shown in Fig. 3. All the samples in the system are assigned an FVP sample number which is used to pull together all analyses done on that sample. In addition to the FVP sample number, all field samples are identified by station, date, depth and replicate, and all laboratory samples are identified by experiment name, principle investigator, experiment number, the date the experiment started and the particular date the

sample was taken. Using these identification variables, all field analysis can be integrated and, separately, all laboratory analyses can be integrated. The integration of field and laboratory analyses is accomplished via the chemistry data.

On-line documentation, accessible to all the project personnel, is maintained and includes a data dictionary describing and locating all variable names. Also provided is a database directory, describing which data are contained in each separate data file and who has access to each data file. Documentation of sample collection dates and stations are maintained on-line in a cruise data file which indicates what analyses should be available for each station, date and depth. Descriptions of each laboratory experiment are maintained, including experimental conditions and treatment descriptions.

3. RESULTS & DISCUSSION

3.1 Disposal Mound Morphology

Pre-disposal bathymetric surveys, conducted on an 800 m2 grid centered over the disposal point, indicated a generally flat bottom with a gentle slope to the south, as evidenced by an increase in depth from 19.5 to 20.5 meters over the survey area (Fig. 4) A side-scan sonar survey, made at the same time, indicated two interesting features. On the western edge of the site, the bottom was more

variable with patches of strongly reflective sediments and detritus. The random distribution of these features tends to indicate spillage of debris from previous disposal operations which had taken place over a long period of time. This was one of the reasons why the station locations for the field assessment studies were located to the east of the disposal point.

Side scan sonar also revealed the presence of a series of troughs oriented in an east-west direction, parallel to the tidal current flow. The stability of these furrows is not known since they were not observed in surveys prior to April 1982. The presence of these furrows was confirmed by diver observations. Aside from these features, the initial surveys showed the FVP site to have characteristics typical of the CLIS disposal site.

An interim bathymetric survey of the site was conducted on May 5, 1983 during disposal, on May 19 immediately following disposal, and again in June, July and August 1983. Contour plots for the May 19 and August surveys are shown in Figs. 5 and 6. Navigation for the disposal of Black Rock Harbor sediments was aided by the use of a taut-wire moored buoy. Fig. 5 shows that the resulting mound was relatively small, approximately 200 X 100 meters, and was oriented in an east-west direction. The maximum topographic relief of the mound was 1.8 to 2.0

meters. Diver surveys over the site during the immediate post-disposal period found that, between 100 and 150 meters from the center of the mound, the dredged material thickness was reduced to a layer several centimeters thick and that the visible margin of dredged material was between 400 and 500 m in the east-west direction and 300-400 m in the north-south direction. Little change in the gross topography of the mound occurred during the summer (Fig. 6); however, a side scan sonar survey showed a general decrease in reflectivity of the disposal mound. This indicated a general reworking of the mound sediments and a deposition of fine-grained material on the surface of the disposal mound. (Scott et al., in prep.)

3.2 Biochemical Response -- AEC

Adenylate Energy Charge (AEC) is a measure of the amount of biochemical energy available to an organism from the adenylate pool. It is an indicator of stress which may be used to gain information on the physiological condition of an organism. It is calculated from measured concentrations of the three adenine nucleotides, adenosine triphosphate (ATP), adenosine diphosphate (ADP) and adenosine monophosphate (AMP), which are integral to the energy metabolism of all organisms. The AEC ratio, which has a range from 0 to 1, represents the internal energy status of the cell from which the condition of the entire

organism can be estimated. Values of AEC are associated with characteristics of environment and organism as shown in Table 1.

AEC ratios for Mytilus edulis were observed in category I for all dates and from primary FVP stations collected through June 1984 with two exceptions. All AEC values for the September 1983 samples were in category II, and values for animals collected for deployment in November 1983 were in category II. However, deployed animals from the November 1983 collections were in category I from all of the FVP stations. AEC ratios have shown no differences between mussels deployed at the primary FVP stations during the course of the study to date.

AEC ratios for Nephtys incisa were observed to be in category II from all stations from post-disposal collections at the FVP site. Pre-disposal collections from stations at 400E and the South Reference station were in category III. September 1983 ratios were all observed to be in category I, however. The Nephtys incisa AEC ratios have not indicated differences between stations at any time during the course of the FVP study to date.

3.3 Cellular Response — SCE

Within the cell, sister-chromatid exchange (SCE) is the interchange of DNA replication products between the arms of a chromosome. This exchange presumably involves

TABLE 1: AEC Ratios and Organism Responses

Category	AEC Ratio	Environment	Organism Responses
I	0.8 - 0.9	non-limiting	high growth rate; reproduction & viability normal
II	0.5 - 0.75	limiting	slow or no growth; no reproduction viability maintained
III	<0.5	severely limiting	no growth or reproduction; viability lost, even after transfer to non-stress conditions

DNA breakage and reunion, although the molecular mechanism is unknown. The SCE response has been determined empirically to be a sensitive measure of mutagenic effects on DNA (Latt et al., 1981). The sensitivity of SCE for detecting mutagens and carcinogens is greater than traditional chromosome and chromatid observations (Latt, 1974; Perry and Evans, 1975; Solomon and Bobrow, 1975; Bloom 1978). The SCE response has been applied previously to the marine polychaete, Neanthes arenaceodentata (Pesch et al., 1981). In the EPA/COE field verification program, we have applied SCE to Nepthys incisa, a polychaete indigenous to Long Island Sound. Both species were included in the laboratory testing phase of the FVP (Johns et al., Chapter OC).

The SCE response has been recommended for environmental applications by U.S. Environmental Protection Agency's Gene-Tox Program (Latt et al., 1981). We are applying the SCE technique to N. incisa collected at the primary field stations in an attempt to evaluate any genetic risks associated with disposal of the BRH sediments. Initial efforts have focused on applying the technique directly to field collected specimens. Active cell division is needed in order to make observations on the chromosomes. Sampling, handling, feeding, holding and labeling all effected the response of N. incisa. The SCE

technique has been applied successfully to field collected specimens and we are collecting data. Preliminary observations indicate no differences among samples from stations 200E, 400E, 1000E and South Reference. However, the SCE frequencies in field specimens are high compared to those in laboratory acclimated specimens. These observations need to be repeated, both in the laboratory under "real-world" simulated conditions and in the field in order to verify the lab-field comparability of data.

3.4 Tissue Response -- Histopathology

At the tissue level, histopathological examination, via the light microscope, can elucidate the effects of pollutants on aquatic animals as it has traditionally for diseases in humans and other mammals (Epstein, 1972). As part of the FVP, examinations were conducted on specific tissues conducted in order to determine whether changes in these structures could be detected that may be related to the disposal activities. These tissues included those of the reproductive and digestive tracts as well as the epidermis of the worm, Nephtys incisa, and the kidneys, gills, and digestive diverticulum of the mussel, Mytilus edulis. Comparisons were made between those animals collected from the disposal site and from the South Reference site.

The worms were sorted for size by sieving at the field

collecting sites, placed directly into Helly's fixative for 4 to 6 hours, then washed in water and stored in 70% alcohol until they could be processed into slides. These studies have not as yet been completed.

Caged mussels, deployed at the primary field stations at monthly intervals from March through October 1983, were examined histopathologically. After being collected and transported live to the laboratory, they were then preserved in Helly's fixative and processed into microscope slides. No histopathologic changes were noted during this period which could be attributed to the BRH dredged material.

3.5 Whole Organism Response

3.5a Scope For Growth

The physiological index, scope for growth (SFG) (Warren and Davis, 1967), is a measure of the amount of energy an organism has available for growth and reproduction, after routine metabolic costs have been accounted for. Lowered SFG measurements have been shown to be ecologically significant through a reduction in fecundity and growth efficiency (Bayne et al., 1981). In the FVP monitoring program, this index has been used to measure chronic effects in Mytilus edulis in order to test for possible effects due to the disposal of BRH dredged material. Results indicate a negative effect on the SFG of

mussels located near the center of the mound in the time period immediately after disposal. Monthly monitoring after this period indicated no effect during the summer months when sea conditions were relatively calm. However, mussels deployed near the center of the pile during the winter months again exhibited statistically lower SFG values. This coincided with winter storm events which may have resulted in resuspension of the dredged material.

3.5b Bioenergetics

Juvenile Nephtys incisa were initially collected from the field with the intent of determining their energy budgets. The plan was to use N. incisa energetics data as a method for monitoring the physiological condition of individuals collected from this indigenous polychaete population. However, measurement of food ingestion rate with this species proved to be unfeasible, and only respiration and excretion rate data could be obtained. Due to this limitation, the plan to use N. incisa energetics data for purposes of physiological monitoring in the field may be discontinued.

3.6 Bioaccumulation

3.6a Organic

The concentrations of organic and inorganic contaminants found in introduced (Mytilus edulis) and indigenous (Nephtys incisa) organisms after exposure at the

disposal and reference sites are being determined. These concentrations offer an organism's view of contaminant exposure to the dissolved and suspended particle bound phases (in mussels) and to the sediments (in worms). Samples analyzed to date show that the levels of PCBs in mussels caged near the disposal site during the disposal operation (at 1000E) and those caged for two weeks after cessation of the disposal activity (at 400E and 1000E) were elevated relative to mussels maintained at the South Reference station, or those held at the disposal site prior to dumping. The trend of increased concentration of PCBs in mussels from the center of the disposal site relative to South Reference organisms continued for time periods up to and including six months after the disposal operation. However, due to variability in measured concentrations at certain time periods, the differences detected were not statistically significant.

At 8 and 16 weeks after disposal was complete, the PCB concentrations in the deposit feeding worm, Nephtys incisa, were elevated at stations near the mound (400E and 1000E) relative to predisposal and South Reference samples. Due to sample size limitations, the differences measured were not statistically significant. At 44 weeks, worms had recolonized the disposal site. PCB concentrations in these organisms and in those from 400E were significantly higher

than those from the South Reference station. Concentrations at 1000E, the farthest experimental station from the mound, were statistically indistiguishable from concentrations at the other experimental stations or at the South Reference station.

As more analyses are performed for metals and other organic compounds and further monitoring samples are collected and analyzed, a more complete picture of contaminant exposure, as reflected by residue accumulation in organisms, will be available.

3.6b Inorganic

Results of analyses conducted on caged mussels deployed at the primary FVP stations prior to disposal indicate no significant difference in tissue chemical residues for Fe, Mn, Cd, Zn, Ni, Pb, Cr, and Cu, (one-way ANOVA, $P<0.05$). Samples collected during disposal activities demonstrate statistically significant elevations in concentrations of Cr and Cu at the 1000E site compared to the South Reference station. Two weeks after disposal activities were completed, but before the station at the center of the pile had been deployed, Cr and Cu were significantly elevated at 400E and 1000E compared to levels observed at the South Reference site. Lead levels were elevated in mussels deployed at 400E as well. No further analyses have been made. It is of interest to note that

during chemical waste characterization conducted as a part of the FVP, Cr, Cu, and Cd in the BRH sediments were found to be 27, 51 and 61 times higher respectively than in surface sediments collected pre-disposal from the study site. Mussels deployed at 400E and 1000E, as indicated above, showed elevated levels of Cr and Cu. Elevated levels of Cd were not observed however.

Worm samples, collected at 400E, 1000E, and South Reference on July 13, 1983 (two weeks after the disposal operation ceased) do not show any difference for any of the trace metals determined for the worm whole body burdens. At the time of this collection, no worms were present at the center of the disposal site. It is planned to analyze worm samples which have since recolonized this site from samples obtained more than a year after the cessation of the disposal operation.

3.7 Population Response -- Demographics

Among the most important parameters of persistence within any ecological community are demographic characteristics of component species' populations. In order to examine commmunity dynamics and the response of the community to man-induced perturbations, information on individual life histories of organisms must be known. Life history features reflect evolved characteristics that are concerned with the ability of a species to persist in a

given environment.

Dr. Robert Whitlatch of the University of Connecticut is examining the life history characteristics (i.e., growth, mortality, fecundity, population growth and stability) of the polychaete, Nephtys incisa, and will determine how these parameters are altered by dredge material disposal at the study site. There are two primary objectives of this work. The first is to develop a population model of Nephtys incisa using existing data collected from Long Island Sound, Narragansett Bay, and Buzzards Bay. This model will provide a baseline of the life history features and population dynamics of N. incisa in natural conditions. The model also will be used to predict how populations behave when influenced by various types of perturbations (e.g., sensitivity of population persistence to changes in growth and fecundity). The second objective is to assess changes in life history features and population dynamics of N. incisa at the Long Island Sound FVP disposal site and determine if the population growth and persistence are modified in the near field environment around the BRH sediment pile.

3.8 Community Responses

Benthic invertebrate larvae are highly sensitive to the nature of the substrate in which they settle (Crisp 1974). The structure and stage of succession of a benthic

community after an anthropogenic disturbance, such as disposal of dredged material, are indicative of the effect and the persistence of that material.

Predisposal benthic community sampling was done to establish the following: 1, overall community structure; 2, small and large scale variability; 3, dominant species; 4, seasonal changes in the community structure; and 5, optimal sampling plans. Samples were taken in May, August, and December 1982, and March 1983. The May and August samples were taken to establish an optimal sampling plan. The sampling plans for these two dates are shown in Table 2. Using the data collected for these samples, the sampling plans for all subsequent sample dates was established. The plan consists of taking five replicate samples at Center, 200E, 400E, 1000E, and South Reference.

Comparisons of community structures and levels of succession will be made at sites increasing in distance from the center of the disposal mound. These comparisons will lead to an understanding of the role of the thickness of the disposed sediment and the effects of different levels of exposure to Black Rock Harbor sediments on the benthic community.

The total number of species found for each sample over all quadrats sampled is listed in Table 3. Differences in the species present at the four sample dates are attributed

TABLE 2 SUMMARY OF PRE-DISPOSAL BENTHIC COMMUNITY SAMPLING

DATE	# OF STATIONS SAMPLED	# OF REPLICATES PER STATION	TOTAL NUMBER OF SPECIES
5/4/82	34	1*	67
8/24/82	13	1, 4, or 8	60
12/8/82	5	5	65
3/15/83	5	5	58

* For 32 stations, 3 each for 1000E and South Reference

TABLE 3 PREDISPOSAL BENTHIC SPECIES VARIABILITY

SPECIES	SAMPLES DATES			
	5/4/82	8/24/82	12/8/82	3/15/83
Nucula annulata				
A		26434	21417	86525
B	73276	4181	3785	.0009
C		71%	69%	110%
D	46%	45%	42%	49%
Yoldia limatula				
A		7.7	1602	1255
B	223.6	.35	788	807
C		62%	59%	59%
D	31%	34%	49%	55%
Mulinia lateralis				
A		214	60325	40160
B	21538	3584	74174	20113
C		88%	49%	80%
D	40%	360%	59%	67%
Nephtys incisa				
A		526	78.4	145
B	948	45.9	0	0
C		57%	30%	48%
D	17%	33%	13%	22%
Mediomastus ambiseta				
A		13138	4,188,051	2,722,969
B	59.7	1214	1,348,882	.027
C		103%	71%	63%
D	67%	61%	51%	28%

A) intra-station variability
B) inter-station variability
C) % change to detect differences between stations
D) % change to detect difference between years

to changes in the rare species present at each season. The ranking of the dominant species changed between dates but not extensively. Fig. 7 shows the species densities versus species rank for each sample date. The communities found in the study area prior to disposal are characterized as classical Nephtys-Nucula communities previously described in Buzzards Bay (Sanders, 1958), Long Island Sound (Sanders, 1956; Rhoads and Young, 1970), and Narragansett Bay (Hale, 1974). Nephtys incisa occurs in mean densities ranging from 400-1430 per square meter. Nucula annulata occurs in mean densities ranging from 3800 to 16500 per square meter. Yoldia limatula occurs in mean densities ranging from 300 to 1200 per square meter. These three species were always ranked in the top ten for each sample date.

The spatial variability for the three top-ranked species identified above was determined for each date. Using the calculated spatial variability, statistically detectable differences in mean densities were calculated for each species at each date. These results are also summarized in Table 3. Small scale (within station) variabilities were not calculated for the May samples because there were only two stations at which replicate samples were taken. For most of the important species considered here, the small scale variability is greater

than the large scale variability. This suggests that the benthic community structure is patchy on a small scale and that this patchiness is fairly consistent over the entire study area. Because of this spatial distribution, it will be difficult to statistically detect differences between stations for a given date unless many replicate quadrats are sampled at each site. Table 3 also shows the magnitude of differences that must be realized between samples in order to detect differences for each of the dominant species. These results suggest only large scale changes between sample dates, such as would be expected during disposal, will be detectable. Of those species discussed here, Nephtys incisa seems to be the most likely candidate as a sensitive indicator of small changes between stations. Clearly, a more sensitive indicator of small differences between communities would be desirable. Other measures such as diversity indices, extremes, transitional species and rare species will also be considered as indicators of small changes in the sampled communities.

3.9 REMOTS Interface Camera

The REMOTS interface camera has had two applications in the FVP. One is as a monitoring tool to assess conditions of the benthic habitat. The parameters measured are boundary roughness, modal grain size, redox depth and area, and successional stage. By combining the

successional stage with redox depths and several other parameters, a habitat index can be be estimated. A full description of these methods is given in Rhoads and Germano (1982), and their application to the FVP is found in Scott et al., 1984 (in prep). A second application of the interface camera is to accurately map the areal extent of dredge material immediately following disposal. The results of REMOTS surveys will be briefly summarized below in three parts: pre-disposal habitat characterization, reconnaisance mapping of the dispersion of Black Rock Harbor sediments, and post-disposal monitoring, through August 1983.

During the pre-disposal phase, REMOTS surveys were conducted in August 1982 and March 1983. In August, 53 stations were occupied and based on the results of this survey, 15 stations were resampled in March. Three replicate photographs were taken at each station. For both dates, redox depth was greater than 4 cm at most stations. The mean modal grain size was silt clay and remained unchanged between dates. The boundary roughness was slightly higher in March, probably resulting from the higher surface erosion due to winter storms. The habitat indices remained above 9.0 for both dates indicating a high quality habitat. These pre-disposal surveys supported other physical, chemical and biological data that the study

site is a high quality, homogeneous habitat.

The areal extent of Black Rock Harbor dredged material was estimated by a reconnaisance survey immediately following disposal on May 24 and 26, 1983. Several stations were added in the June 14 survey in the east-west direction to more accurately map the dredged material. On these surveys, the thickness of the dredged material was measured on the margins but could not be accurately determined on the mound because thicknesses were greater than the depth of penetration of the camera prism (20 cm). Dredge material thickness on June 13 is shown in Fig. 8. The cross-hatched area to the west represents an uneven dredged material thickness with patches and clumps probably resulting from the scows beginning to open as they approach the disposal buoy at the center of the map. The zero isopleth (including the area of random distribution) is overlaid on the bathymetric contour chart for that date. These results indicate that both methods, precision bathymetry and REMOTS, used in conjuction give a very good estimate of dredged material dispersion.

Post-disposal surveys of the FVP site were made on June 13, July 19 and August 29, 1983. In June, the mean redox depth was 2 cm or less inside the zero isopleth while it was 3.7 or greater on the ambient seafloor. Habitat indices were less than 5 in the affected area as compared

to indices of 5 to 11 on the ambient bottom. By July 19, there had been progressive depression of the redox depth from a mean of 1.6 cm to 2.2 cm. The depression of the redox was related to the irrigation activities of the colonizing tubicolous polychaetes. There was a concomitant improvement in the modal habitat index from 3 to 4. The distribution of these two parameters is shown in Fig. 9. The establishment of deposit feeding polychaetes on the mound by the August survey resulted in an increase in the average redox depth of 0.6 cm. The more complete colonization of the mound area also resulted in an increased modal habitat index to 5 (Fig. 10). As shown in Fig. 11, the habitat index improved approximately one unit per month, mainly as a result of irrigation activities of the colonizing tubicolous polychaetes and the later addition of head-down deposit feeders.

4. CONCLUSIONS

The long-range goal of the monitoring program, as described here, is to apply a series of biomonitoring tools and then to evaluate their effectiveness in describing the effects of disposed material. It must be emphasized, however, that this evaluation relates only to this one site in Central Long Island Sound and with this one waste, Black Rock Harbor dredged material. Clearly, the effectiveness of the techniques found to be most suitable in this study

may change with different site and waste characteristics.

In these monitoring studies, as in the effects assessment component of the FVP, the responses have been tiered so as to examine the biota from the subcellular to the whole organism level, to the population, and finally to the natural community levels. To date, results at the lower tiers, particularly adenylate energy charge, sister-chromatid exchange, and histopathology, have not shown any significant effects of Black Rock Harbor dredged material for the immediate post-disposal period. Mussel scope for growth measurements have shown an effect during and immediately following disposal and during winter storm events occurring 10 months after disposal as well. Studies are on-going, and the long-term responses in the near-field will be determined.

The residue analyses have shown elevated levels of some contaminants in both the worm, Nephtys, and the mussel, Mytilus; however, the biological significance of these body burdens has not yet been determined other than to conclude that these organisms have been exposed to the Black Rock Harbor dredged material. This aspect of the FVP, the residue-effects relationship, is of great concern and will be addressed in this program as well as others.

The population studies are just now getting underway and will assess the population response of the infaunal

polychaete, Nephtys, from preserved samples collected throughout the course of the program as part of the community studies.

The community studies form the foundation from which to describe an ecological basis for the entire FVP. The response of the natural assemblage is an integrative one and one which may not be able to be predicted through the tiered monitoring approach. These community effects are being assessed using two approaches, a classical quantitative description of the community structure and a more qualitative description of the functional properties of the benthos through the REMOTS procedure. These two methods have demonstrated the obvious physical effects of the disposal operation in the creation of a defaunated area by simple burial. The critical questions to be addressed are what is the long term pattern of recolonization of the denuded area and what is the the spatial extent of community effects. The qualitative approach will describe what is happening and where, while the quantitative studies will describe what components of the community are responsible for those changes.

ACKNOWLEDGMENTS

This project was supported by the U.S. Army Corps of Engineers, Waterways Experiment Station Environmental Laboratory with Dr. Richard Peddicord and Dr. Tom Dillon as Project Managers. The EPA Technical Director was Dr. Jack Gentile. We would like to thank G. Pesch and W. Nelson for their critical comments on the manuscript. We would also like to thank the following researchers at ERLN who assisted in various phases of the monitoring project. G. Hoffman, R. Lapan, K. Schweitzer, W. Boothman, and F. Osterman assisted in the trace metal analyses. P. Rogerson, J. Lake, S. Pavignano, R. Bowen, L. LeBlanc, A. Elskus, and C. Norwood, assisted in the organic chemistry analyses. G. Zaroogian and M. Johnson assisted in the AEC analyses. P. Yevich, C. Yevich, E. Peters, M. Casey assisted in the histopathology analyses. W. Galloway, G. Tracey, N. Rubinstein, and D. Moffatt (U. Conn) assisted in the diving. Other assistance was provided by J. Heltshe, P. Sherman, W. Giles, and C. Katz. Special thanks are due also to the crews of the R/V UCONN, R/V Shang Wheeler, and the Hazel W. III.

REFERENCES

Bass, L. J. 1982. DATMAN Terminal User's Guide, Version 4.0. Technical Report TR82-165. University of Rhode Island, Kingston.

Bayne, B.L., Clark, K.R., and M.N. Morse. 1981. Some Practical Considerations in the Measurement of Pollution Effects on Bivalve Molluscs, and Some Possible Ecological Consequences. Aquatic Toxicology, 1, 159-174.

Bloom, S.E. 1978. Chick Embryos for Detecting Environmental Mutagens. In: Chemical Mutagens: Principles and Methods for Their Detection, Vol. 5, A. Hollaender and F.J. deSenes, eds., Plenum Press, New York and London, pp 203-232.

Crisp, D.J. 1974. Factors Influencing the Settlement of Marine Invertebrate Larvae. In: Chemoreception in Marine Organisms. P.T. Grant and A.M. Mackie, eds., Academic Press, New York and London.

Epstein, S.S. 1972. Environmental Pathology -- A Review. American Journal of Pathology, 66, 352-373.

Hale, S.S. 1974. The Role of Benthic Communities in the Nutrient Cycles of Narragansett Bay. Masters Thesis, University of Rhode Island, Kingston.

Latt, S. 1974. Sister Chromatid Exchanges, Indices of Human Chromosome Damage and Repair: Detection by

Fluorescence and Induction by Mitomycin C. Proceedings of the National Academy of Sciences, (Washington, D.C.) 71, 3162-3166.

Latt, S.A., J. Allen, S.E. Bloom, A. Carrano, E. Falke, D. Kram, E. Schneider, R. Schreck, R. Tice, B. Whitfield, and S. Wolff. 1981. Sister Chromatid Exchange: A report of the Gene-Tox Program. Mutation Research, 87, 17-62.

Morton, R.W. 1982. Site Selection and Baseline Surveys of the Black Rock Disposal Site for the Field Verification Program. Science Applications, Inc. DAMOS Contribution 24.

Perry, P. and J.H. Evans. 1975. Cytological Detection of Mutagen-Carcinogen Exposure by Sister Chromatid Exchange. Nature (London), 258, 121-125.

Pesch, G.G., C.E. Pesch, and A.R. Malcolm. 1981. Neanthes arenaceodentata, A Cytogenic Model for Marine Genetic Toxicology. Aquatic Toxicology, 1, 301-311.

Rhoads, D.C. and J.D. Germano. 1982. Characterization of Organism-Sediment Relations Using Sediment Profile Imaging: An Efficient Method of Remote Ecological Monitoring of the Seafloor. (REMOTS (TM) Systems) Marine Ecology Prog. Series 8, 115-128.

Rhoads, D.C. and D.K. Young. 1970. The influence of deposit feeding organisms on the sediment stability

and community structure. Journal of Marine Research, 28(2), 150-178.

Sanders, Howard L. 1956. Oceanography of Long Island Sound, 1952-1954. Vol. X. Biology of marine bottom communities. Bulletin of the Bingham Oceanographic Collection, 15, 345-414.

Sanders, Howard L. 1958. Benthic studies in Buzzards Bay. I Animal sediment relationships. Journal of Limnology and Oceanography, 3(3), 245-258.

Scott, K. J. et al. 1984. The Field Verification Program: The Pre-disposal and Immediate Post-disposal Monitoring Studies. Science Applications, Inc. (in prep.)

Solomon, E. and M. Bobrow. 1975. Sister Chromatid Exchanges: A Sensitive Assay of Agents Damaging Human Chromosomes, Mutation Research, 30, 273-278.

Warren, C. E. and G. E. Davis. 1967. Laboratory Studies on the Feeding, Bioenergetics and Growth of Fish, In: The Biological Basis of Freshwater Fish Production, S. D. Gerking, ed., Blackwell Scientific Publications, Oxford, pp 174-219.

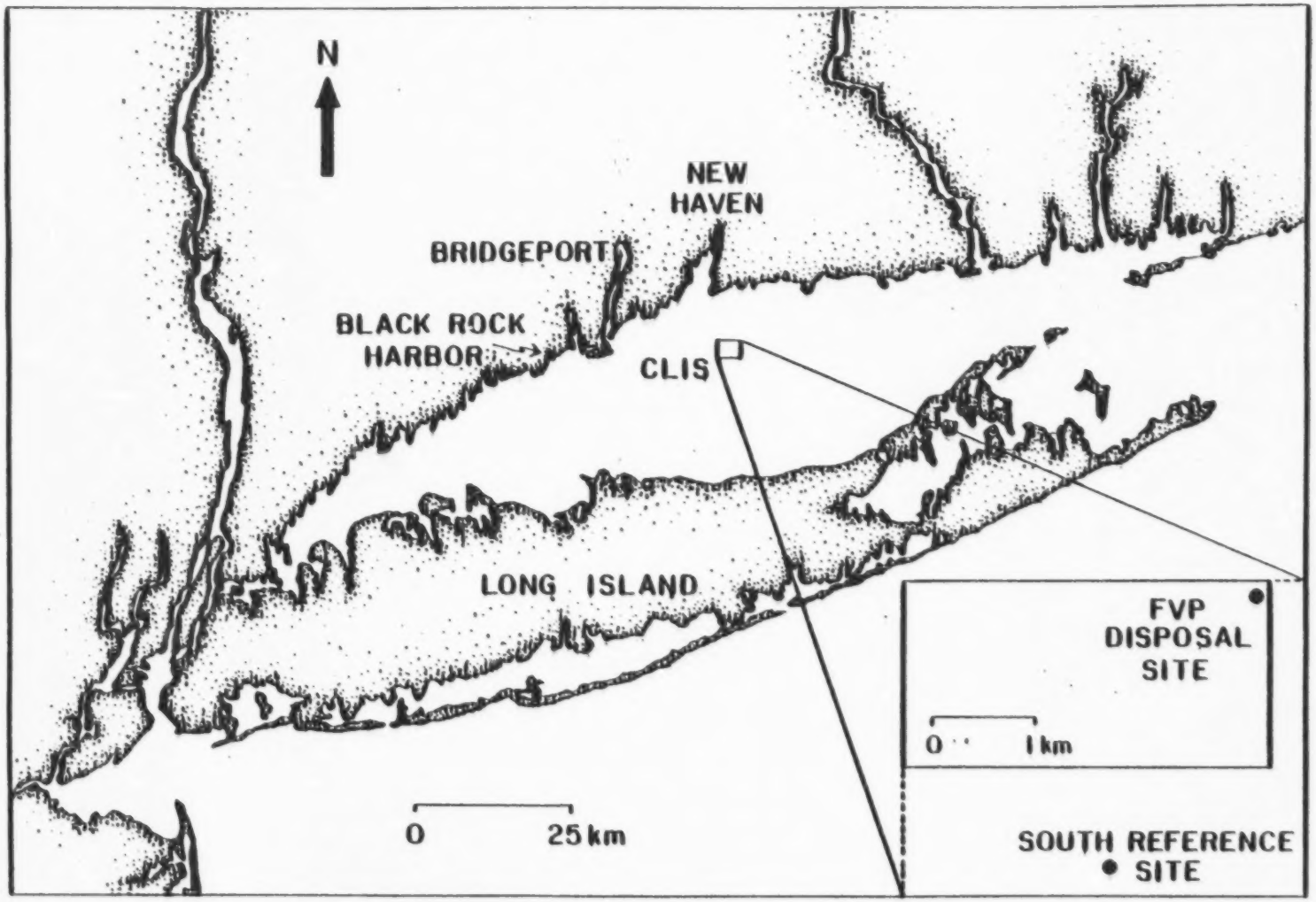


Figure 1. FVP Disposal Site -- Long Island Sound

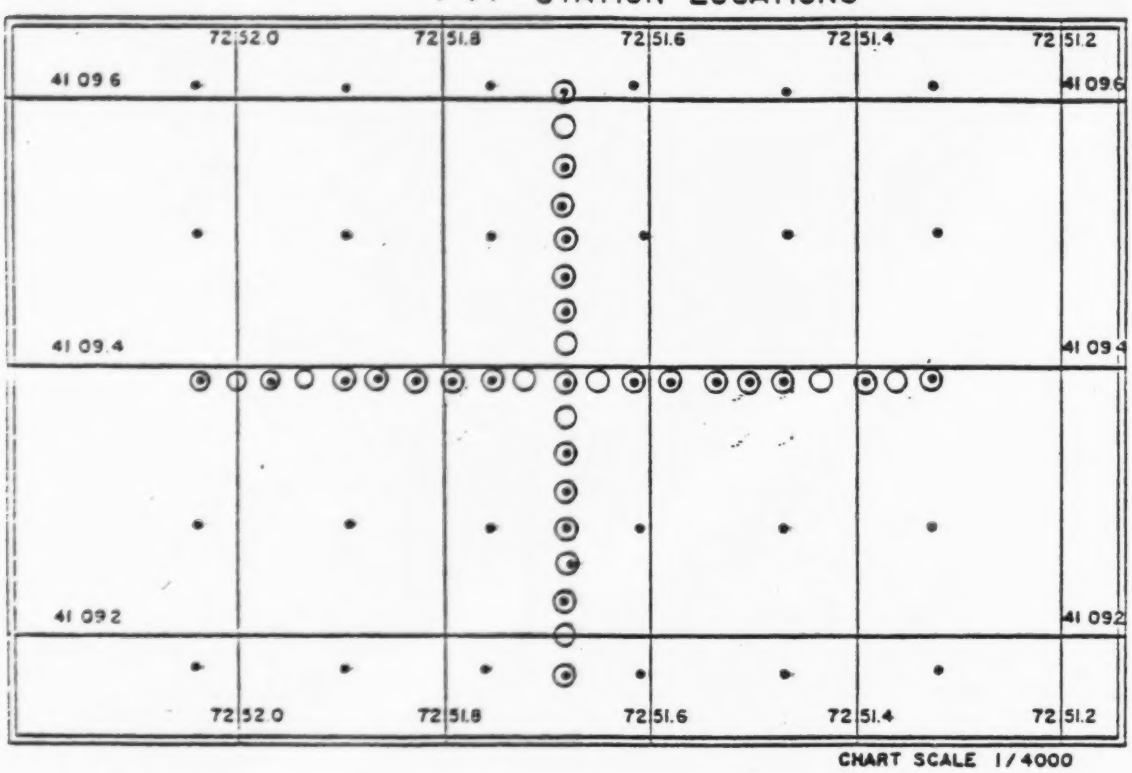


Figure 2a. Benthic Community and REMOTS Stations

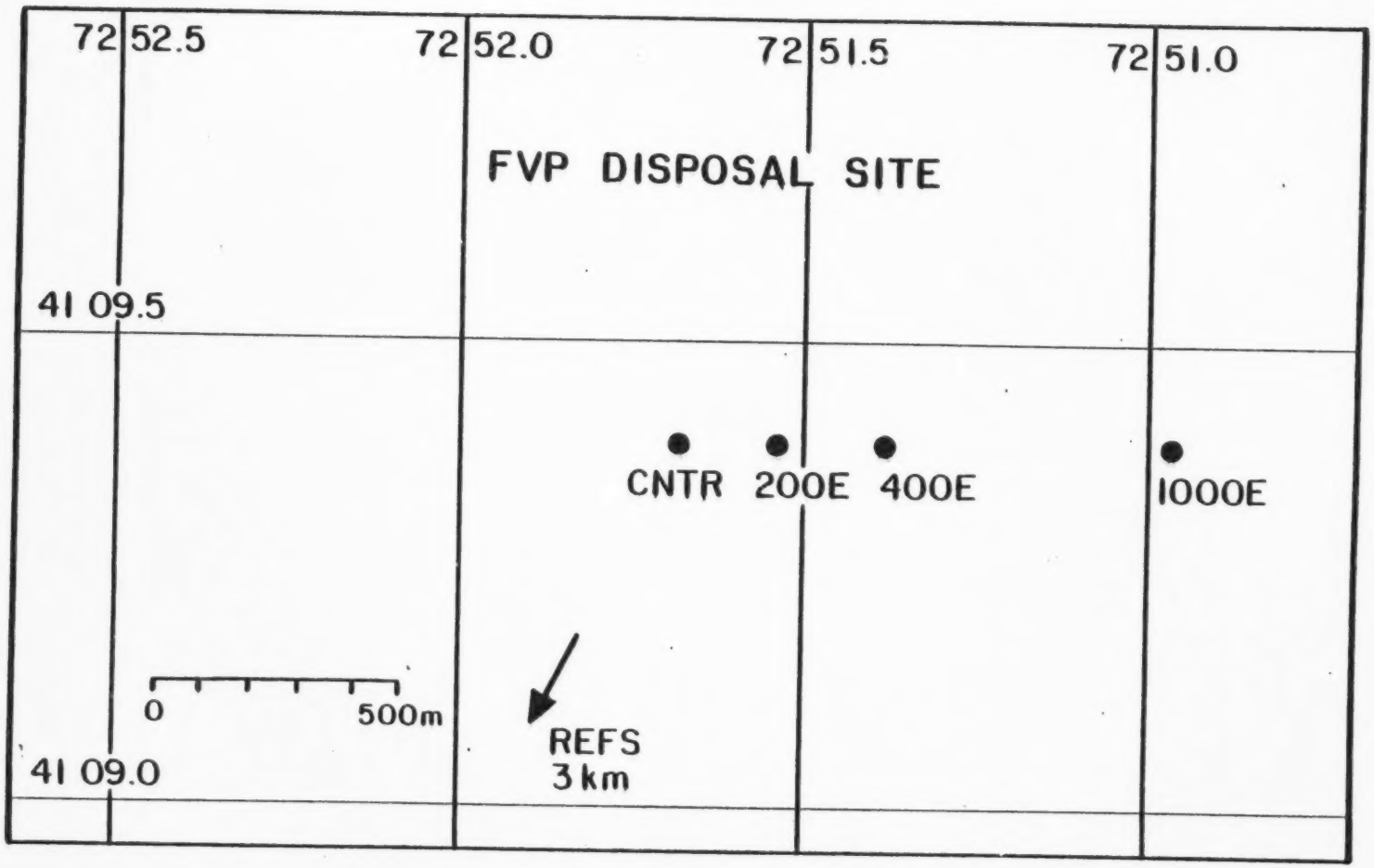


Figure 2b. Major FVP Sampling Stations

ARMY CORPS OF ENGINEERS - FIELD VERIFICATION PROGRAM
DATABASE STRUCTURE

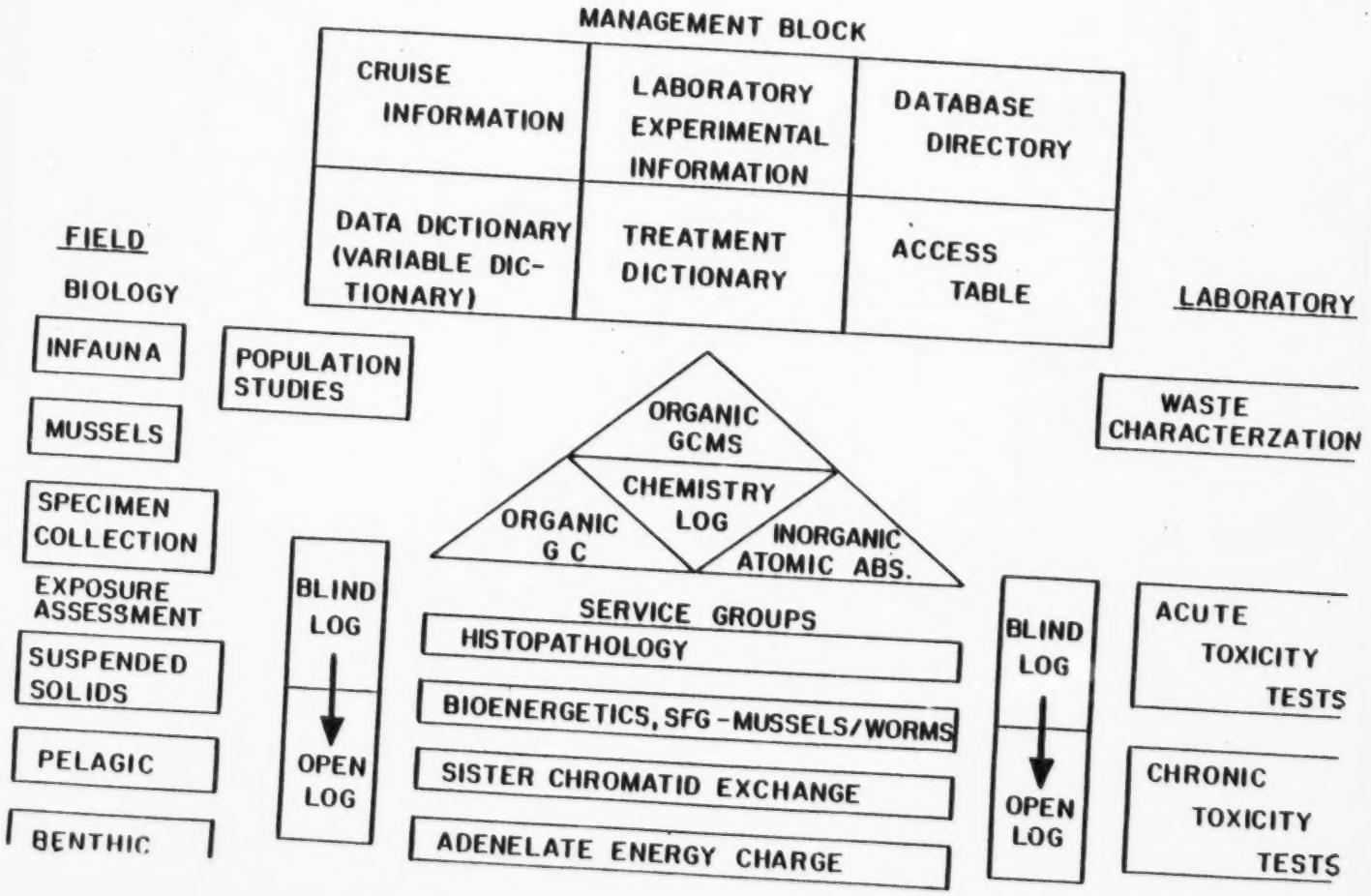


Figure 3. Data Management System

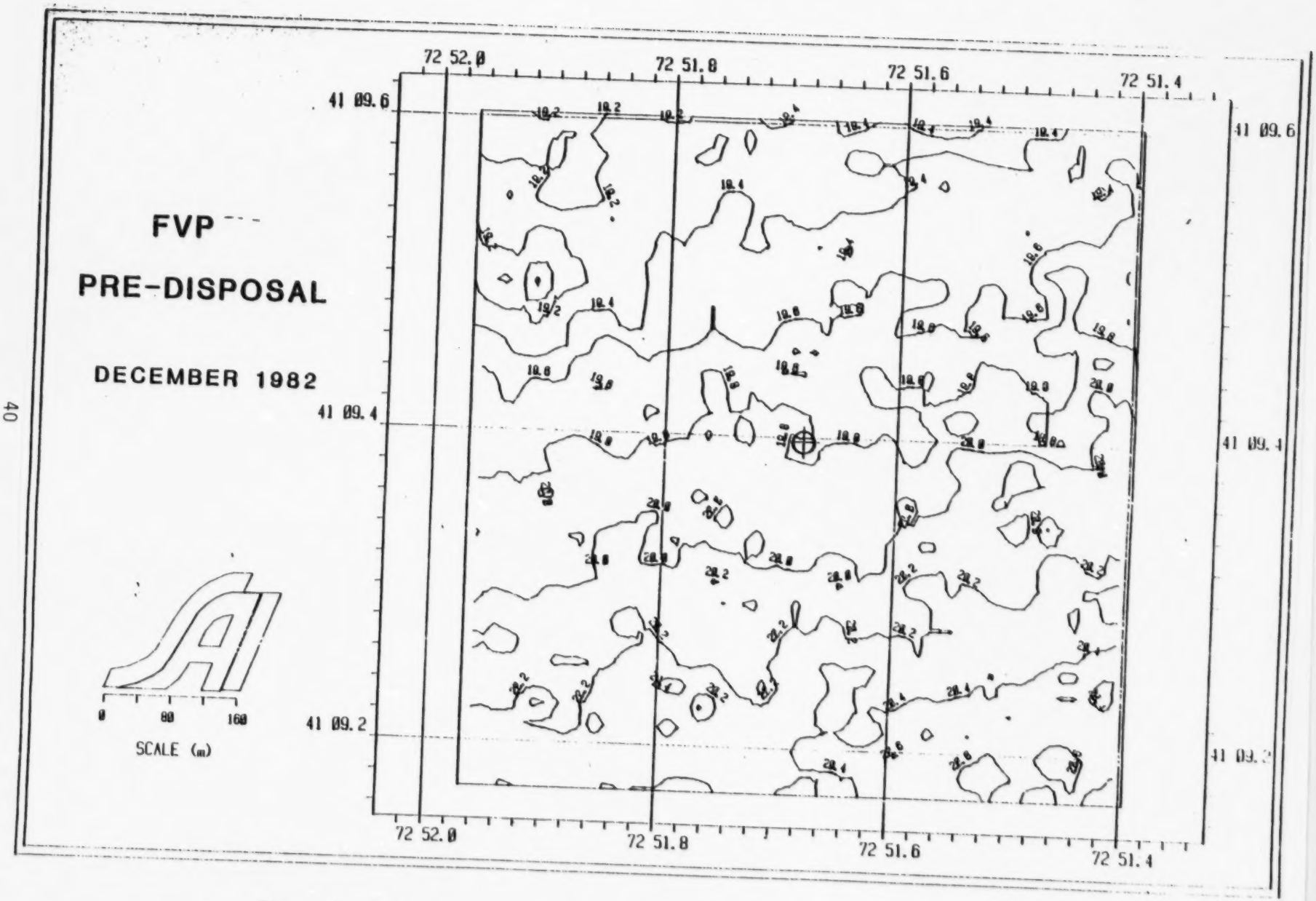


Figure 4. Bottom Topography Before Disposal, December 1982

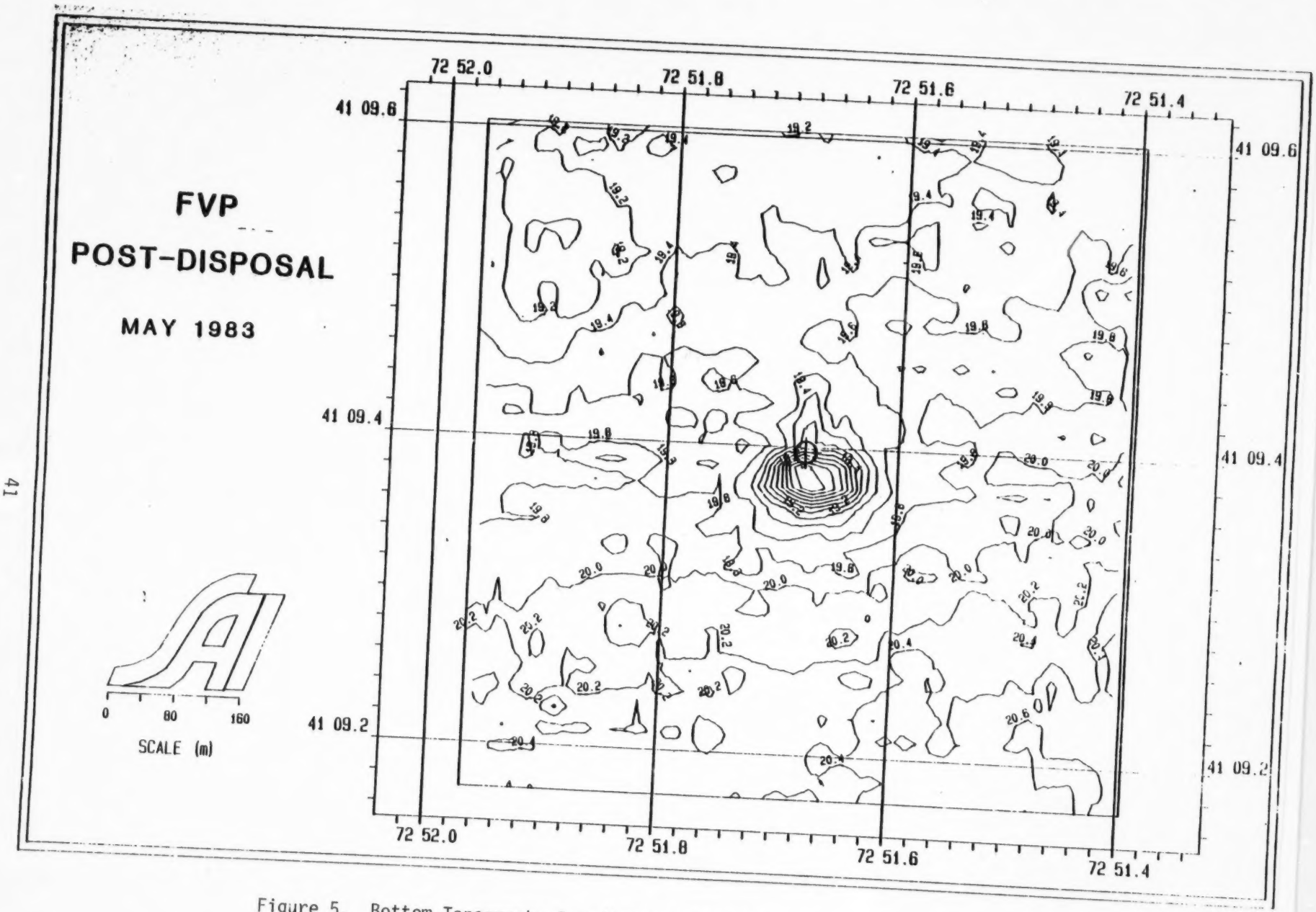


Figure 5. Bottom Topography Immediately After Disposal, May 1983

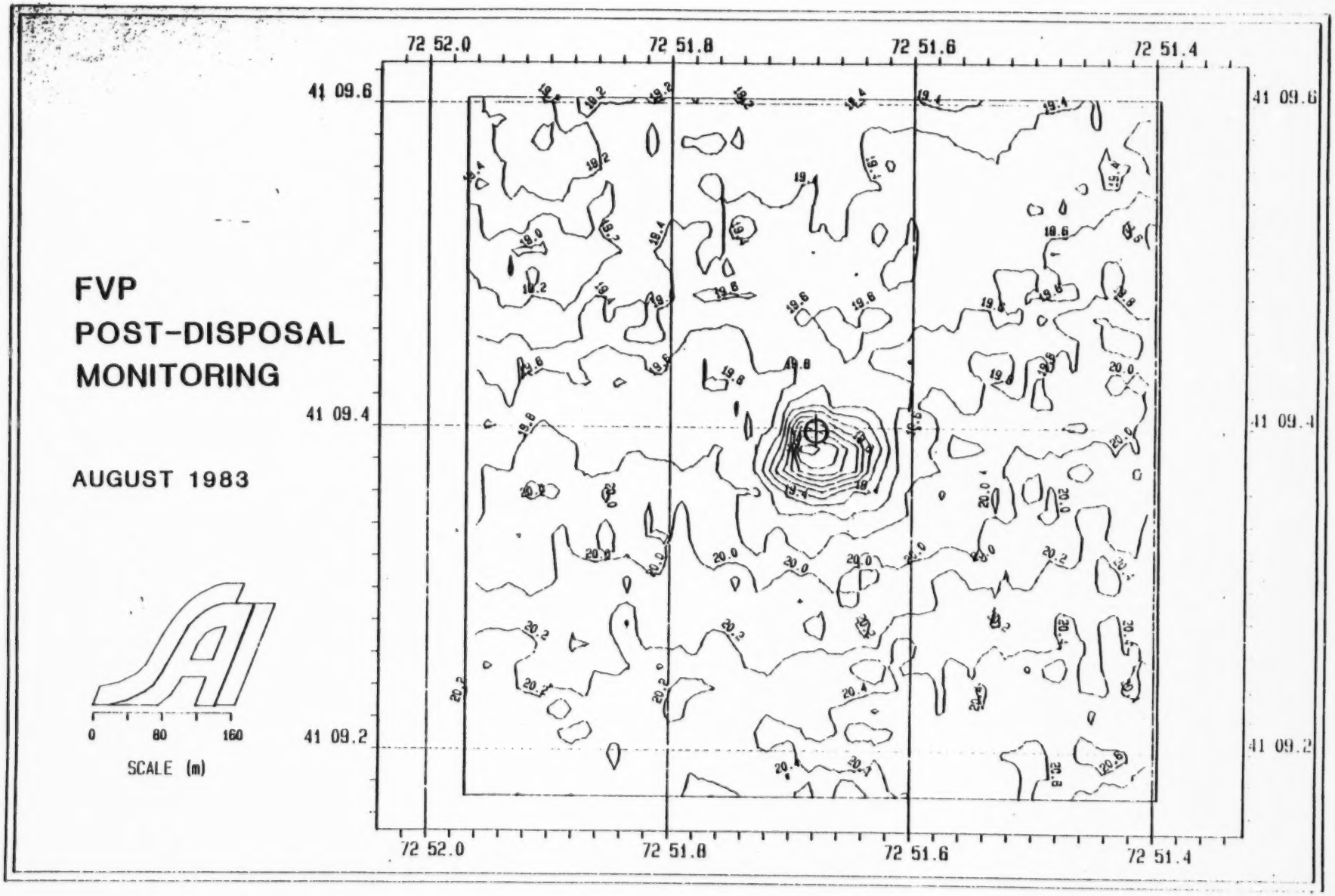


Figure 6. Bottom Topography 3 Months After Disposal, August 1983

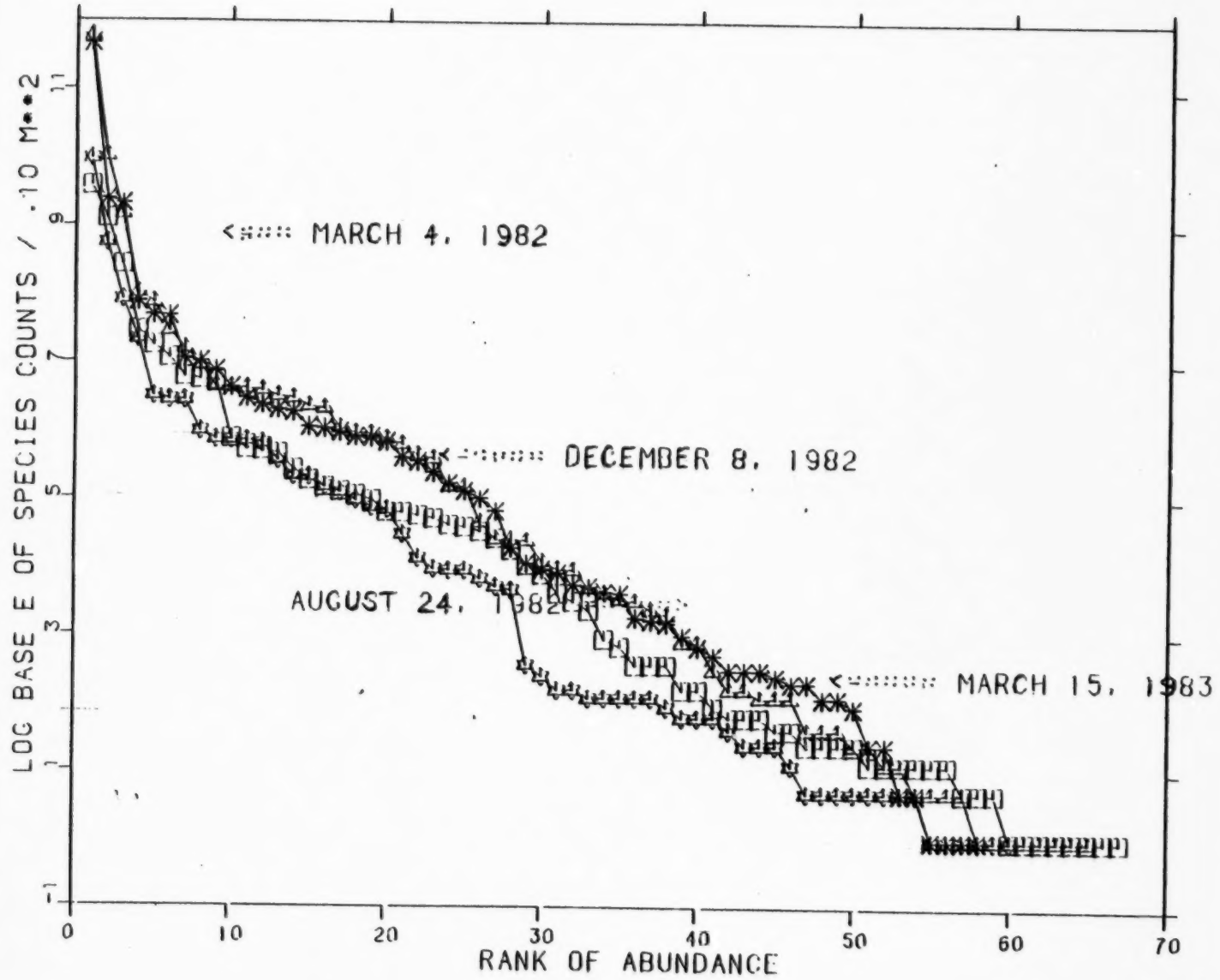


Figure 7. Abundance Ranks and Densities of Benthic Species

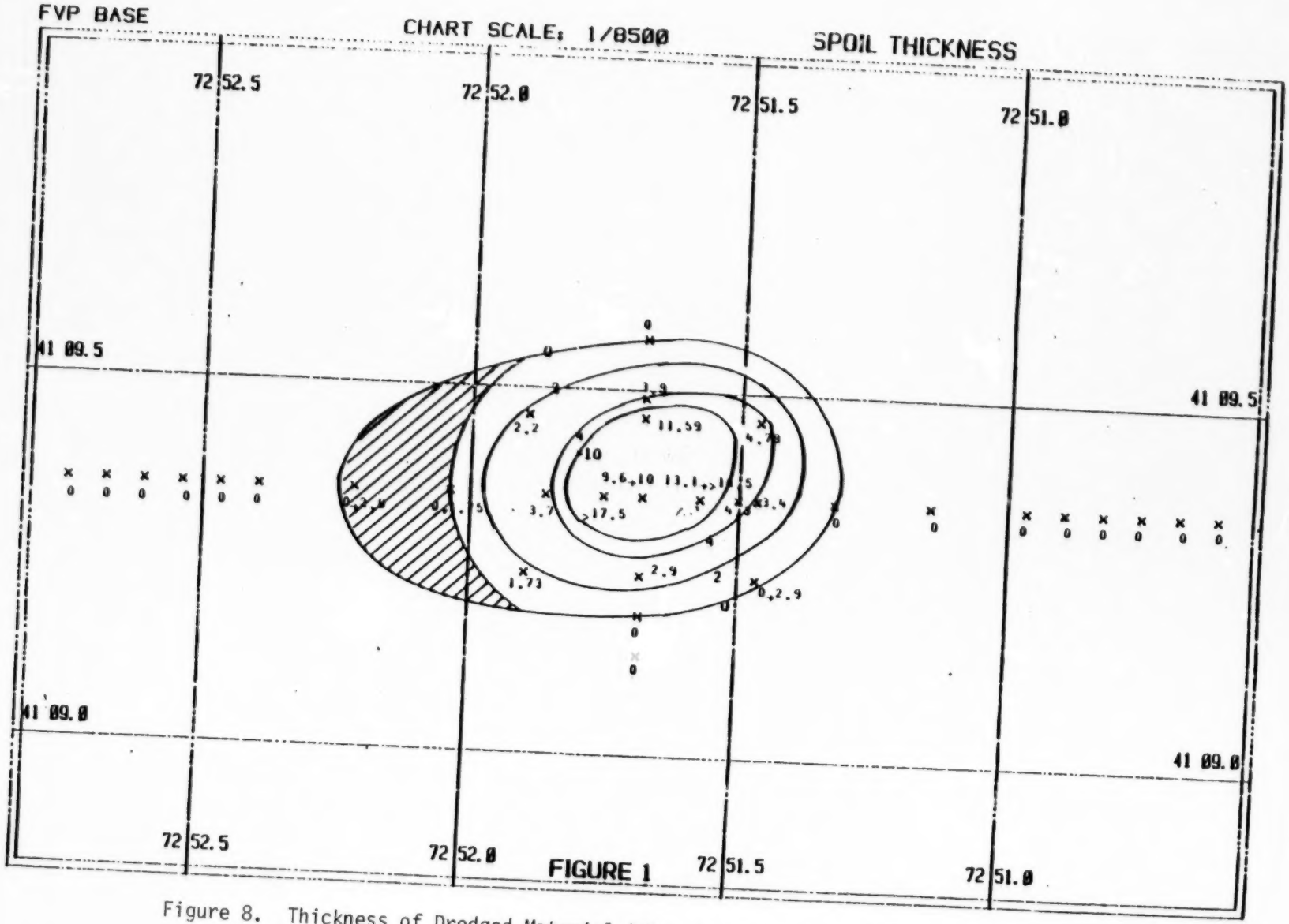


Figure 8. Thickness of Dredged Material After Disposal, June 1983

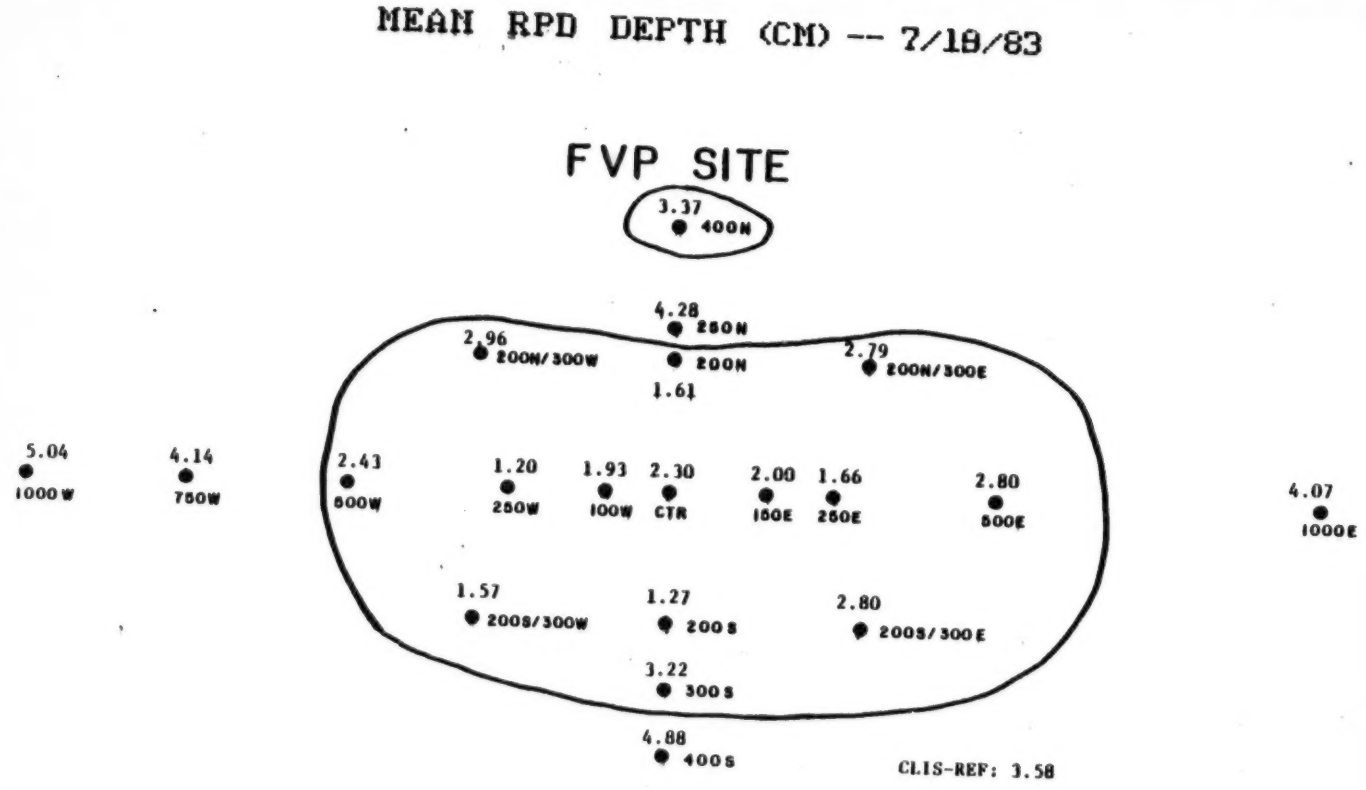


Figure 9a. Mean Redox Depth (cm), July 1983

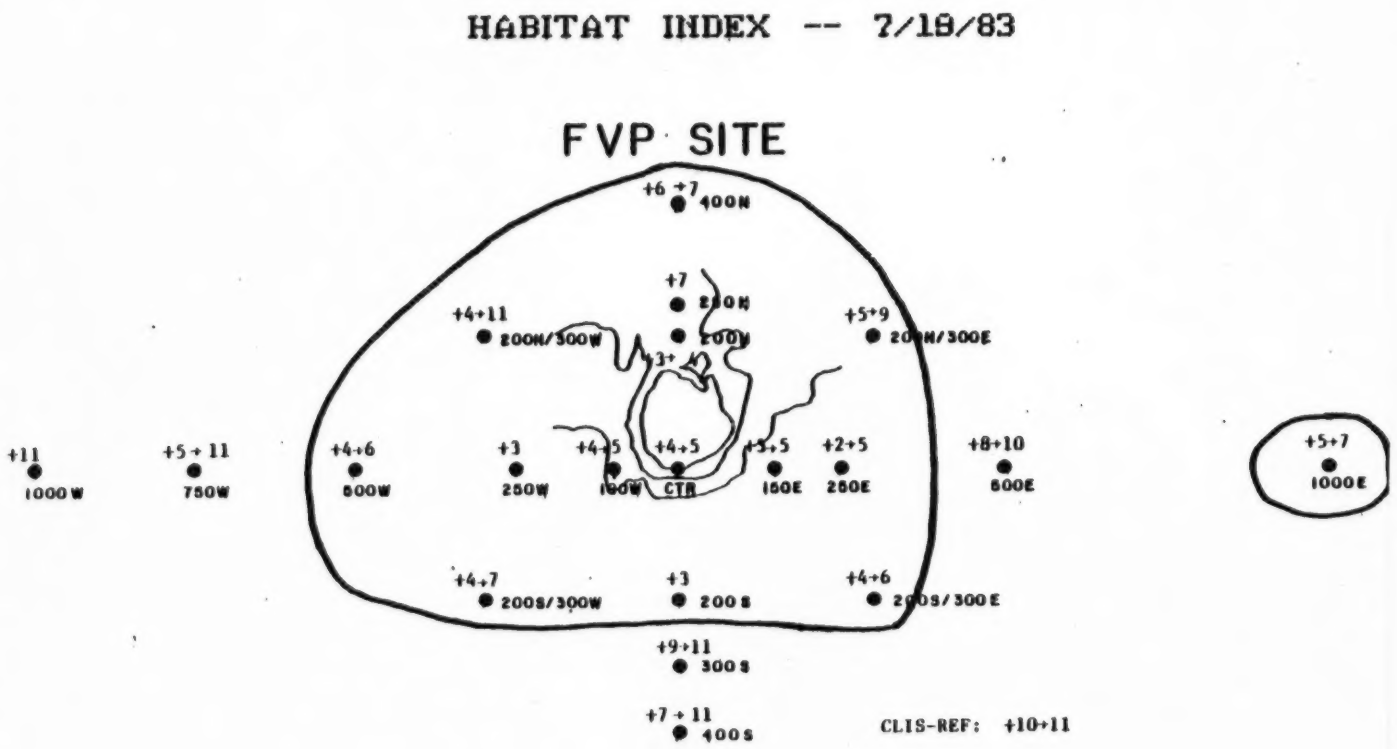


Figure 9b. Habitat Indices, July 1983

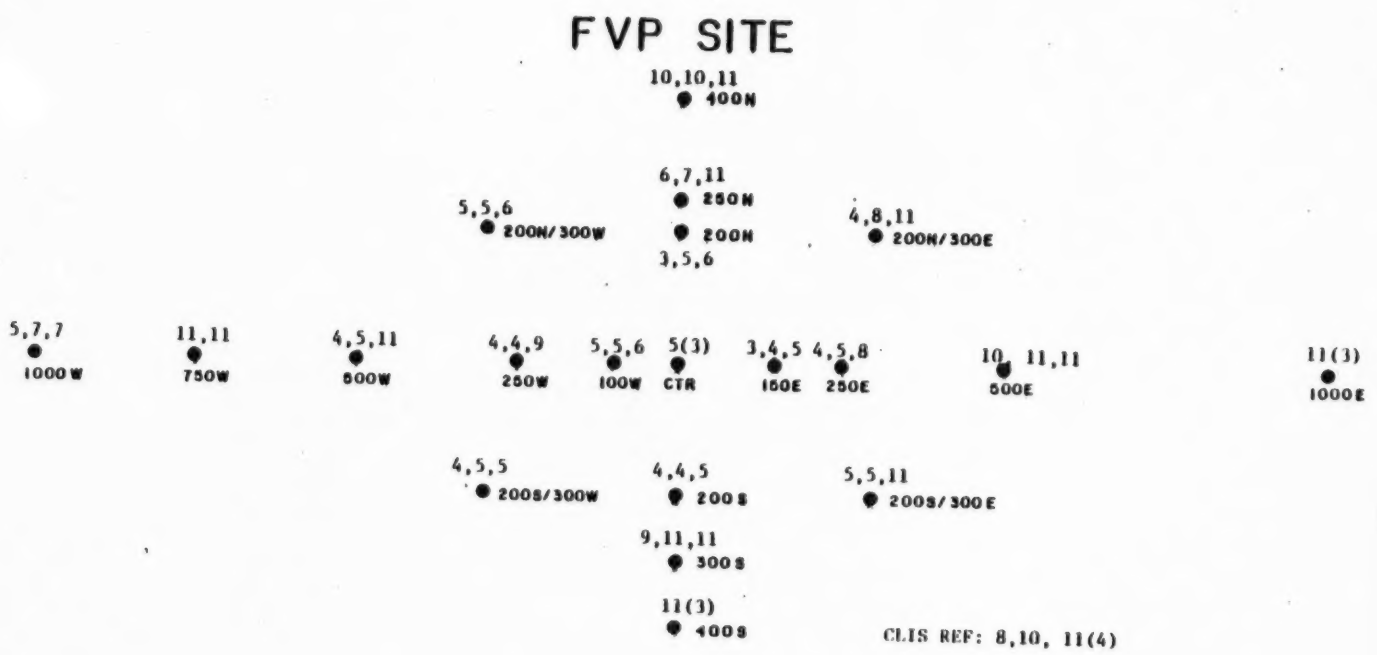


Figure 10a. Mean Redox Depth (cm), August 1983

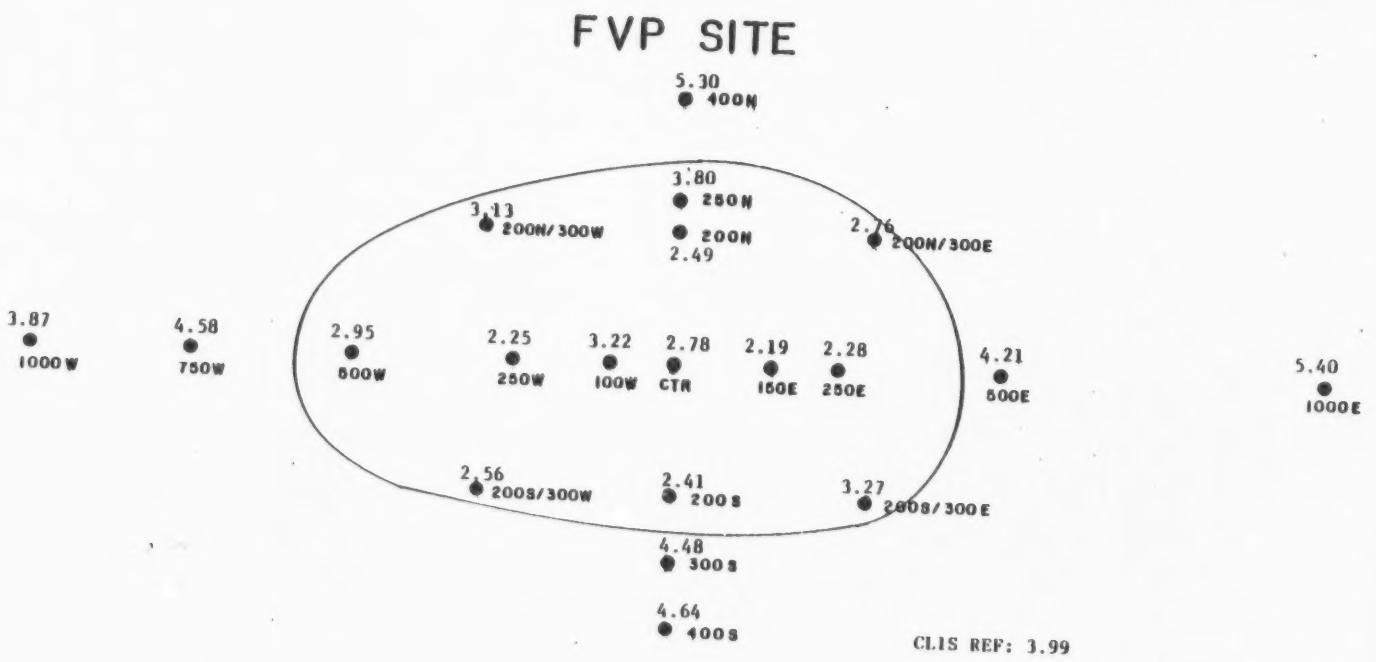


Figure 10b. Habitat Indices, August 1983

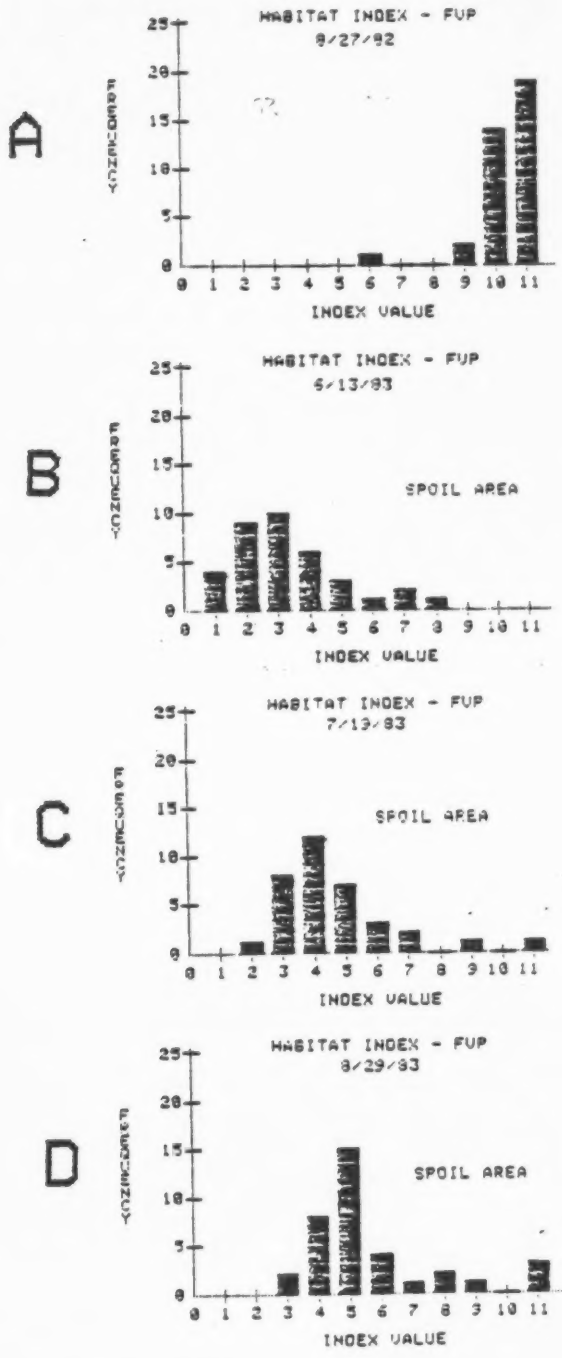


Figure 11. Frequency Distribution of Habitat Indices